Great Salt Lake Playa and Salt Flat UV Albedo Adjustments

This modeling protocol changed the extent of the Great Salt Lake (GSL) to better reflect the actual lake conditions during the 2017 modeling episode. Newly exposed lakebed (or playa), and areas that have been exposed over longer periods of time, have a much higher UV albedo than water itself. Increases in these higher albedo surfaces have implications for increased photochemical reactions due to higher actinic flux. Increasing surface area of GSL playa is not a new or ephemeral phenomenon. Data from the USGS suggests that lake levels between 2017 and 2022 (current year) have further decreased by ~ 5 vertical feet, and the lake surface area has decreased by about 60% since its peak in the 1980s.[1]

Newly-exposed lake playa and highly reflective salt flats and salt crust were identified using 2018 National Agriculture Imagery Program (NAIP) RGB satellite imagery. Playa extent surrounding the Great Salt Lake was further refined following work by Perry et al. (2019)[2]. Figure 1 shows the resulting landuse types.

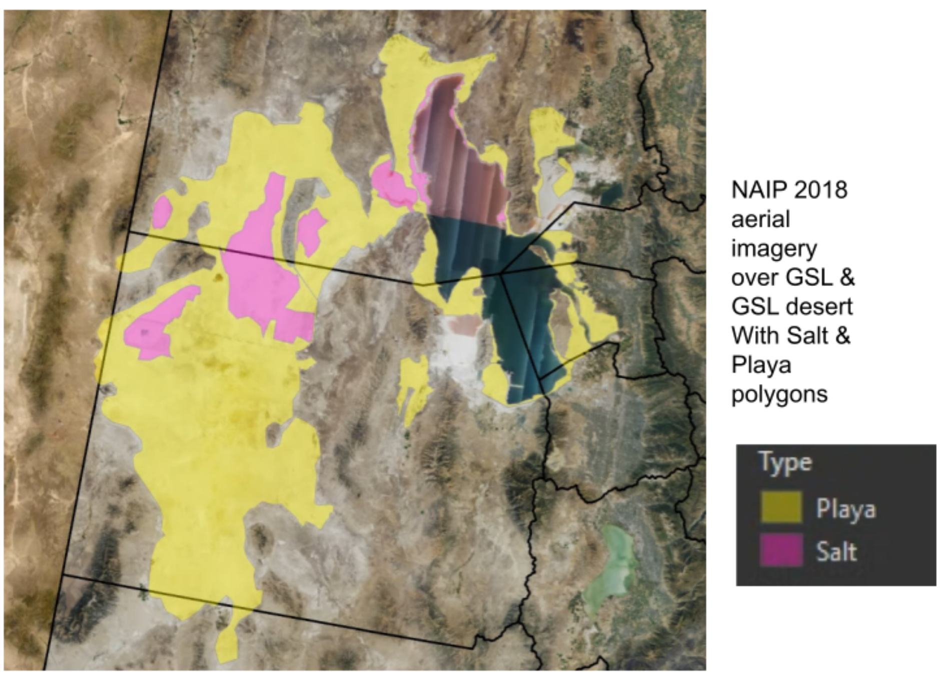

Figure 1: New landuse types added to the CAMx modeling platform for ozone SIP analysis.

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[1]Great Salt Lake Hydro Mapper: https://webapps.usgs.gov/gsl/index.html#salinity
[2] Perry, K. D., Crosman, E. T., Hoch, S. W., Results of the Great Salt Lake Dust Plume Study (2016-2018), available at: https://d1bbnjcim4wtri.cloudfront.net/wp-content/uploads/2019/12/10101816/GSL_Dust_Plumes_Final_Report_Complete_Document.pdf

CAMx uses a time-invariant 2-D surface file that assumes UV reflectance of 0.04-0.08 for most land surfaces, and a value of 0.08 for deserts or desert-like surfaces such as the playa and salt flats around the GSL.[3] These default landuse values are inadequate for surfaces around the GSL, so NAIP imagery from 2018 was used to identify regions of ultra-high reflectivity (from the salt flats) and areas of increased reflectivity from playa surfaces. These classifications are based on visible light reflectance, which is not directly relatable to UV-light reflectivity. Unfortunately, few direct UV albedo measurements exist, and a literature review was conducted to justify increasing albedo values for both the salt flats and exposed playa. A paper published by Turner and Parisi (2018)[4] included UV albedos (*value*) for surfaces including white sandy soil (*9.1*), white clay (*12*), limestone (*11.2*), and a salt lake (*69 +/- 2*), the last of which were measurements made at the Salar de Uyuni in Bolivia. A comparative analysis of MODIS albedo values of the Salt Flats, GSL playa, White Sands New Mexico, and the Salar de Uyuni are summarized in the table below.

Table 1: Comparative analysis of MODIS black sky, white sky, and monthly surface albedos for specific areas.

Area	Daily White Sky Albedo (bihemispherical reflectance)	DATE	Daily Black Sky Albedo (directional hemispherical reflectance)	DATE	Monthly Surface Albedo	DATE	Notes: these areas are likely not showing data because they reflect light in a similar band to clouds. Values in this table are generally chosen from available data around the edges of the salt, playa, or dune.
GSL Playa	342-345	June 20, 2022	300-315	June 20, 2022	0.230-0.235	June 20, 2021	Playa was selected in the dry lake bed surrounding the GSL
GSL Salt	588-591	June 20, 2022	492-495	June 20, 2022	0.315-0.320	June 20, 2021	Salt flat was selected near Utah western border and I-80
Uyuni	600-603	June 20, 2022	591-594	June 20, 2022	0.395-0.400	June 20, 2021	Selected dates during Southern hemisphere wintertime to ensure the Salar de Uyuni is dry and not covered with water
White Sands	594-597	June 20, 2022	489-492	June 20, 2022	0.235-0.240	June 20, 2021	
							Black-sky albedo and white-sky albedo mark the extreme cases of completely direct and completely diffuse illumination. Actual albedo is a value which is interpolated between these two as a function of the fraction of diffuse skylight which is itself a function of the aerosol optical depth

Salt Flat Albedo Adjustment

Both the Utah salt flats and the Salar de Uyuni are highly reflective salt-based crusts which can flood seasonally and are the remnants of prehistoric lakes.[5] [6]

[3]CAMx user guide: https://camx-wp.azurewebsites.net/Files/CAMxUsersGuide_v7.10.pdf

[4] Turner, J.; Parisi, A.V. Ultraviolet Radiation Albedo and Reflectance in Review: The Influence to Ultraviolet Exposure in Occupational Settings. Int. J. Environ. Res. Public Health 2018, 15, 1507. https://doi.org/10.3390/ijerph15071507

[5] Risacher,F., Fritz,B. Quaternary geochemical evolution of the salars of Uyuni and Coipasa, Central Altiplano, Bolivia. Chem. Geol., 90 (3) (1991), pp. 211-231, https://doi.org/10.1016/0009-2541(91)90101-V

[6] Lund,W. R; Geology of Salt Lake City, Utah, United States of America. Environmental & Engineering Geoscience 1990; xxvii (4): 391–478. doi: https://doi.org/10.2113/gseegeosci.xxvii.4.391

Due to the lack of local UV albedo measurements for the salt flats, a value of 69 was chosen based on the similar composition of the two surfaces, and the comparative analysis in Table 1. The area identified as salt flat in Figure 1 was therefore increased from 0.08 to 0.69.

GSL Play Albed Adjustment

The University of Utah (UU) has a measurement network that, as of 2022, includes UV radiation measurements over GSL exposed playa. Data collection at this site (UUPYA) began in June of 2017 and is ongoing. Figure 2 includes sites in the UU measurement network, with UUPYA indicated with a white arrow.

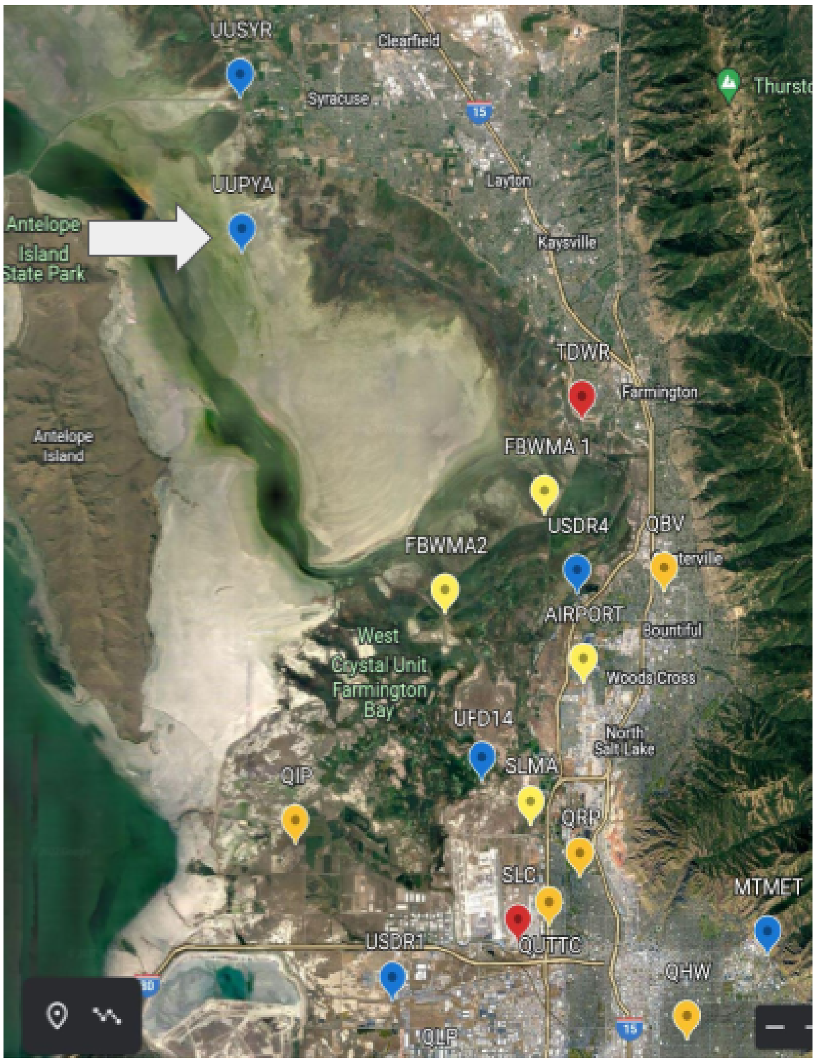

Figure 2: Location of UUPYA on GSL playa.

Total incoming solar radiation and UV albedo were variable through the month of July. The UV albedo (outgoing UV radiation divided by incoming UV radiation) has erroneous data at sunrise, sunset, and during the night (albedo values > 0.5), which are removed in later processing. A change in UV albedo baseline midway through the month was due to two rain events on July

13th and 15th that thinly covered the playa surface and changed the reflectance until evaporation (Figure 3).

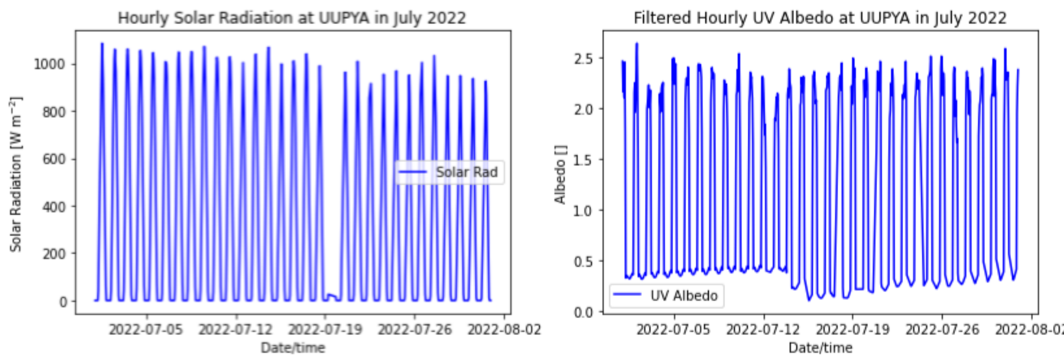

Figure 3: Solar radiation and UV albedo for the month of July

The daily mean albedo (filtered to ignore values from division errors) stays fairly constant on an hourly basis. Figure 4 includes plots for the hourly albedo values for the average of all July days (e.g. the 10 am hour is an average of the 10 am values for 31 days, n=31). The right panel includes only the daytime hours when UV albedo is relevant. The maximum and minimum values reflect day-to-day variability and a change in albedo due to rain events in mid-July.

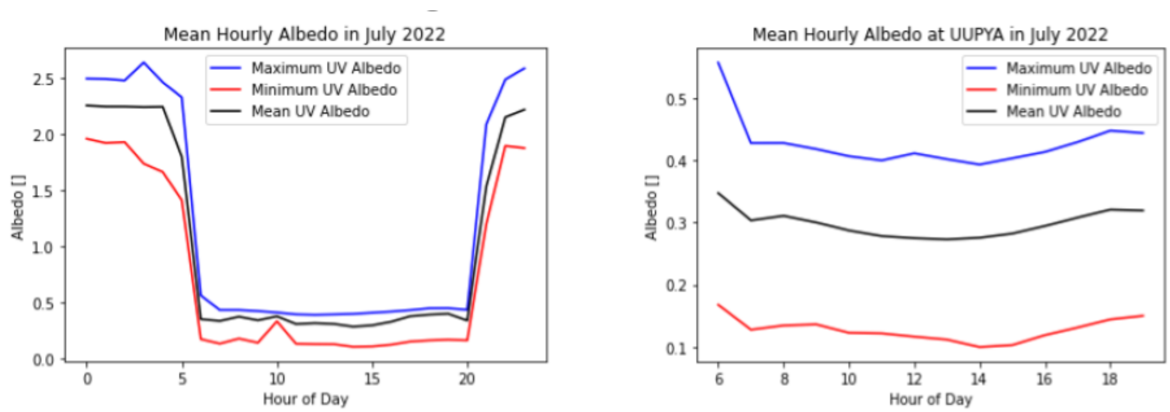

Figure 4: Mean, maximum, and minimum July UV albedo values for the entire day (left panel) and only the daytime hours (right panel).

The mean UV albedo for daytime hours is 0.34 or a 34% albedo, and blanket value of 0.34 was applied to all GSL playa identified in Figure 1 for the duration of the modeling episode.

A value of 0.34 is conservative, as it includes data during ~ 2-weeks of decreased reflectance after rain events and is an average of the entire month. We believe selecting a conservative value is prudent due to the lack of additional monitoring data and the use of a 2022 albedo value on similarly characterized surfaces for a 2017 modeling episode.